



09/825,991
00684.003175

CONDUCTIVE LIQUID CRYSTAL DEVICE
AND ORGANIC ELECTROLUMINESCENCE DEVICE

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JAN 15 2003
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→ FIELD OF THE INVENTION AND RELATED ART ←

5 The present invention relates to an
electroconductive liquid crystal device, particularly
a conductive liquid crystal device useful as an
organic electroluminescence device (hereinafter, the
term "electroluminescence" ^{is} ~~being~~ sometimes abbreviated
10 as "EL" according to common usage in the field).

As for the organic EL device, carrier
injection-type EL devices utilizing organic solids,
such as anthracene single crystal, were studied in
detail in ^{the} ~~years of~~ 1960's. These devices were of a
15 single layer-type, but thereafter Tang, et al, proposed
a lamination-type organic EL device comprising a
luminescence layer and a hole transporting layer
between a hole injecting electrode and an electron
injecting electrode. The luminescence mechanism in
20 these injection-type EL devices commonly includes
stages of (1) electron injection from a cathode and
hole injection from an anode, (2) movement of
electrons and holes within a solid, (3) re-^{com} ~~com~~ bination
of electrons and holes, and (4) luminescence from the
25 resultant single term excitons.

A representative example of the lamination-
type EL device may have a structure including an ITO

film as a cathode formed on a glass substrate, a ca. 50 nm-thick layer formed thereon of TPD (N,N'-diphenyl-N,N'-di(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine), a ca. 50 nm-thick layer thereon of Alq3 (tris(8-quinolinolato)-aluminum), and further a vacuum deposition layer of Al-Li alloy as a cathode. By setting the work function of the ITO used as the anode at 4.4 - 5.0 eV, the hole injection to TPD is made easier, and the cathode is composed of a metal which has as small a work function as possible and also is stable. Examples of the cathode metal may include Al-Li alloy as mentioned above and also Mg-Ag alloy. By the above organization, green luminescence may be obtained by applying a DC voltage of 5 - 10 volts.

15 An example using a conductive liquid crystal as a carrier transporting layer is also known. For example, D. Adam, et al. (Nature, Vol. 371, p. 141-) have reported that a long-chain triphenylene compound as a discotic liquid crystal material exhibited a mobility of 10^{-3} - 10^{-2} cm²/V.sec in its liquid crystal phase (Dh phase) and a mobility of 10^{-1} cm²/V.sec in its mesophase (an intermediate phase, not a liquid crystal phase). Also, as for a bar-shaped liquid crystal, Junichi Hanna (Ohyou Butsuri) (Applied Physics), Vol. 68, No. 1, p. 26-) has reported that a phenylanthracene compound exhibited a mobility of 10^{-3} cm²/V.sec or higher in its smectic

B phase.

As a trial for using such a liquid crystal
for electroluminescence, ^{ngan STAPFF} INGAH STAPFF et al. (Liquid
Crystals, Vol. 23, No. 4, pp. 613-617) have reported
5 an organic EL device using a triphenylene-type
discotic liquid crystal. Other reports are found in
POLYMERS FOR ADVANCED TECHNOLOGIES, Vol. 9, pp. 463-
460 (1998), and ADVANCED MATERIALS (1997), Vol. 9, No.
1, p. 48.

10 Convention^d organic EL devices have involved
several problems attributable to the use of a low^g
molecular weight compound in a crystal state. A first
problem is that the efficiency of injection of
electrons or holes from electrodes of ITO, etc., to
15 the organic layers is low. This is ^{due to a} ~~because~~ minute
grain boundary ^{in a crystal state} of organic molecules ^{which}
functions ^{as a carrier conduction barrier}.
Accordingly, organic molecules in an amorphous state
are generally used, though ^{it results} ~~it incurs a low~~ carrier
20 injection efficiency. This, however, ^{is} ~~has provided~~ a
major ^{reason} ~~cause~~ why an organic EL device cannot ensure a
large current.

25 An organic material used in an organic EL
device has an electronic structure providing a large
energy gap of ca. 3 eV or larger, thermal excitation-
type free electrons are not present in a conduction
band ^{and} ~~a~~ drive current (spatial charge restriction

current) is principally supplied by injected carriers from the electrodes, so that a low carrier injection efficiency from the electrodes has been a serious problem. As the injection efficiency is low, a large voltage has to be applied in order to ensure a drive current, and the device layer thickness has to be lowered. These factors have caused difficulties, such as a short circuit between the electrodes and an increase in capacitive load.

As a second problem, an organic EL device is liable to be affected by ^{invasive} ~~invaded~~ moisture ^{which} ~~to cause~~ ^{the} deterioration of luminescence performance and drive performance, ^{and} thus ~~showing~~ poor durability. In an ordinary organic EL device, the organic layers are disposed in lamination, and then the cathode is formed thereon by vapor deposition of a metal film. In this instance, a metal species having a small work function suitable for the cathode is susceptible ^{to} ~~of~~ oxidation and has a low durability. Even ^{when} ~~in case of~~ forming a protective film thereon by sputtering, the organic layers are liable to be degraded if the forming temperature is high (with an ordinary limit of 100 °C), and the destruction of the device structure due to the film stress is also problematic.

On the other hand, as a problem accompanying the use of a conducive liquid crystal ^{to} ~~for~~ constituting ² a carrier transporting layer, it is difficult to align

a high order liquid crystal layer. As a high order conductivity can be attained by a regular stacking of π -electron conjugated planes of liquid crystal molecules, the degree of alignment thereof directly
5 affects the conductivity of the resultant conductive liquid crystal layer. In the case ~~case~~ of a poor alignment characteristic, trap sites for conduction of electrons and holes can be formed in the liquid crystal layer, so that electroconductivity can be lost
10 ~~at all~~ ^{completely} in some cases.

→ SUMMARY OF THE INVENTION ←

A generic object of the present invention is to provide an improvement to the above-mentioned state
15 of ^{the} art.

A more specific object of the present invention is to provide a conductive liquid crystal device including a conductive liquid crystal layer having locally different regions by ~~controlling~~
20 partially or entirely controlling the alignment state of a conductive liquid crystalline organic layer formed on an electrode.

Another object of the present invention is to provide a conductive liquid crystal device wherein
25 such a conductive liquid crystal layer is provided with locally different conductivities and a memory characteristic, thereby causing luminescence

exhibiting different luminances at an identical drive voltage.

According to another aspect of the present invention, there is provided an organic
5 electroluminescence device comprising: a conductive liquid crystal device which includes a pair of oppositely disposed electrodes and a liquid crystalline organic layer disposed between the electrodes, wherein the organic layer has plural
10 regions having mutually different alignment states resulting in different luminances of luminescence from the device.

The present invention further provides an organic electroluminescence device comprising: a
15 conductive liquid crystal device which includes a pair of oppositely disposed electrodes and at least two organic layers disposed between the electrodes, wherein said at least two organic layers include at least one liquid crystalline organic layer having
20 plural regions of different electroconductivities resulting in different luminances of luminescence from the device.

These and other objects, features and advantages of the present invention will become more
25 apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the

accompanying drawings.

→ BRIEF DESCRIPTION OF THE DRAWINGS ←

Figure 1 is a schematic sectional view of an
5 embodiment of the conductive liquid crystal device
according to the invention.

Figure 2A is a schematic sectional view of an
organic EL device according to Example 1 of the
invention, and Figure 2B is a corresponding bottom
10 plan view.

Figure 3 is a schematic sectional view of an
organic EL device according to Example 2 of the
invention.

15 → DESCRIPTION OF THE PREFERRED EMBODIMENTS ←

According to an embodiment, the conductive
liquid crystal device of the present invention may be
produced by forming a conductive liquid crystalline
organic layer on an electrode, and controlling an
20 alignment state of the conductive liquid crystalline
organic layer locally or entirely to form regions of
mutually different electroconductivities, leading to
different luminances of luminescence when used as an
organic EL device.

25 A high electric field on the order of 10
volts/100 nm has been required ^{to} ~~for the~~ drive of an
organic EL device ^{due to} ~~because of~~ (1) a low _{mobility of} ^{carrier} ~~carrier~~

~~carriers~~ (holes and electrons) through organic layers and (2) ~~a low efficiency of injection of carriers into~~ the organic layers from the electrodes. Organic materials used in organic EL devices have a broad band gap of ca. 3.0 eV, so that thermal excitation-type free electrons are not present in a conduction band (LUMO: ~~Lowest Unoccupied Molecular Orbital~~), and drive current is principally supplied by a tunnel current injected from the electrodes. The injection efficiency of the current is known to be remarkably affected not only by the work functions of the electrodes and ~~a~~ ^{the} level gap between LUMO and HOMO (Highest Occupied Molecular Orbital) of the organic materials, but also by the molecular alignment and structure of the organic materials. However, in order to attain a sufficient drive current ~~by~~ using ordinary organic compounds (such as TPD, α -NPD (bis[N-(1-naphthyl)-N-phenyl]benzidine), TAZ-01 (3-(4-biphenyl)-4-phenyl-5-(4-tert-butylphenyl)-1,2,4-triazole), Alq3, etc.) in ordinary EL devices, it has been necessary to apply a high electric field (on the order of 10 V/100 nm) across the organic layer-electrode boundaries. Further, as the mobility of the organic materials is on the order of 10^{-6} - 10^{-3} cm²/V.sec, it is also necessary to apply a high electric field in order to ensure a drive current. Some improvement ^{with regard} to the above problem has been ^{found} ~~given~~ by using a conductive liquid

crystal for constituting a liquid crystalline charge injection layer as proposed by our research group (EP-A 1083613 and EP-A 1089596).

5 The use of a conductive liquid crystal for constituting a charge injection layer is effective because of the following reasons and functions.

(1) Some conductive liquid crystalline^{materials} have a mobility exceeding 10^{-2} cm²/V.sec (D. Adam, et al., Nature[✓], Vol. 371, p. 141-).

10 (2) A conductive liquid crystal causes a phase transition at a higher temperature to assume a lower order liquid crystal phase, such as nematic phase or discotic disordered phase, thereby showing a good alignment characteristic to cause alignment of liquid
15 crystal molecules over an electrode surface.

(3) Especially, a discotic liquid crystal generally has a structure including a core of, e.g., triphenylene, and side chains attached to the periphery of the core for developing mesomorphism
20 (liquid crystal property). The side chains generally exhibit poor wettability with ~~a substrate~~ of a metal or ~~a~~ metal oxide (such as ITO)^{substrate}, so that in the liquid crystal state of the discotic liquid crystal, the core is aligned parallel to the electrode surface, whereby
25 the π -electron resonance plane of the core is aligned parallel to the electrode surface, thereby facilitating carrier transfer with the electrode.

Accordingly, it is possible to provide a higher injection efficiency than an ordinary organic compound in an amorphous state.

This effect can also ^{be} expected for an ordinary
5 bar-shaped liquid crystal having a molecular structure including a phenyl group or a naphthalene group having a π -electron resonance plane.

(4) The formation of a conductive liquid crystal layer as a carrier transporting layer by vacuum
10 deposition is particularly effective. A liquid crystal film layer formed by vacuum deposition has a coarse molecular packing state, the re^oalignment thereof by heating is very easy. This is particularly true with a liquid crystal film formed by vacuum
15 deposition on a substrate at a temperature close to or below T_g (glass transition temperature) of the liquid crystal giving a stably coarse film structure.

(5) A high-order liquid crystal phase having a higher degree of order has a low fluidity; and the
20 alignment thereof in the high^o-order liquid crystal phase per se is difficult, whereas the alignment characteristic thereof can be improved if the liquid crystal layer is sandwiched between films having a power of aligning π -electron conjugated planes
25 parallel thereto. Realignment by heating ~~up~~ to the isotropic phase is not desirable for device formation sometimes because of ~~a strong dissolving power of the~~

has a strong dissolving power
with respect

liquid crystal material in a liquid phase^{to other}
organic materials;^{however,} ~~but~~ the dissolution problem is not
encountered at a boundary with a metal film. In the
case of sandwiching a liquid crystal with metal films,
5 one of them is required to allow light transmission.
For example, in the case of using a gold film, the
film may be formed as an island-like uneven film, but
the alignment thereby of a liquid crystal ~~can be~~ ^{as compared to that}
improved ~~than~~ in the absence of such a gold film.

10 (6) A molecule exhibiting mesomorphism can re-
organize molecular disposition at the electrode
surface by re-aligning post treatment. This can
facilitate the injection efficiency. The post
treatment can exhibit a large effect even when it is
15 performed by heating only to a liquid crystal phase
temperature if it provides a lower viscosity. The
heating to the isotropic temperature, while it is
effective for the re-alignment, has to be suppressed
to a temperature below the Tg of other organic
20 materials used together therewith.

(7) At a boundary of a luminescence layer with a
liquid crystal layer or an intermediate metal layer,
it is effective to insert a protective layer
comprising a material having a function of
25 transporting ~~a carrier~~ of the same type.

In the present invention, such a conductive
liquid crystal layer is formed while noting the above

points, so as to provide regions of different electroconductivities by locally changing the alignment state thereof.

The local alignment state change is principally performed by local heating of the conductive liquid crystalline organic layer. This can alternatively be effected by a surface treatment of an electrode surfaces, such as local surface roughening at regions for not aligning the liquid crystal on the electrode surface.

The conductive liquid crystal device structure including a conductive liquid crystal layer having a locally different conductivity can be effectively used ^{to} ~~for~~ constituting^e an organic EL device as described in detail below but also ^{to} ~~for~~ constituting^e other functional devices, such as a photosensor, a photoconductor (electrophotographic photosensitive member), an organic semiconductor device (such as an organic TFT), a temperature sensor, and a space modulation device.

Figure 1 is a schematic sectional view of an embodiment of the conductive liquid crystal device according to the present invention. Referring to Figure 1, the conductive liquid crystal device includes a transparent substrate 1, ~~and~~ a transparent electrode (anode) 2, a liquid crystalline organic layer 3, a luminescence layer 5 and a metal electrode

(cathode) 6 disposed, in this order, on the substrate 1,
~~wherein~~ the liquid crystalline organic layer 3 is
provided with plural regions having mutually different
electroconductivities including non-aligned liquid
5 crystal regions 3a having a lower conductivity and
aligned liquid crystal regions 3b having a higher
conductivity.

The liquid crystalline organic layer 3
comprises a liquid crystalline or mesomorphic compound
10 having a liquid crystal phase at some temperature,
inclusive of low^g-molecular weight (non-polymeric)
conductive liquid crystals and polymeric conductive
liquid crystals. The conductive liquid crystal may
suitably have a π -electron resonance structure, which
15 is generally given by an aromatic ring. Examples
thereof may include: triphenylene ring, naphthalene
ring and benzene ring, as representative, and also
pyridine ring, pyrimidine ring, pyridazine ring,
pyrazine ring, tropone ring, azulene ring, benzofuran
20 ring, indole ring, indazole ring, benzothiazole ring,
benzoxazole ring, benzimidazole ring, quinoline ring,
isoquinoline ring, quinazoline ring, quinoxaline ring,
phenanthrene ring and anthracene ring.

The conductive liquid crystal used in the
25 present invention may preferably comprise a discotic
liquid crystal or a smectic liquid crystal. A
discotic liquid crystal may generally have a core

structure which may be given by an aromatic ring as mentioned above for the π -electron resonance structure, as represented by triphenylene ring (or skeleton). Further examples thereof may include
5 truxene skeleton, metal-phthalocyanine skeleton, phthalocyanine skeleton, dibenzopyrene skeleton, metal-naphthalocyanine skeleton, dibenzopyrene skeleton, and hexabenzocoronene skeleton.

As for the electrode materials used in the
10 present invention, examples of materials^{which may} constituting^e the anode 2 may include: indium oxide, tin oxide, Cd_2SnO_4 , zinc oxide, copper iodide, gold and platinum, in addition to ITO used in^{the} Examples described hereinafter. Examples of materials^{which may} constituting^e the
15 cathode 6 may include: alkali metals, alkaline earth metals and alloys of these, inclusive of sodium, potassium, magnesium, lithium, sodium-potassium alloy, magnesium-indium alloy, magnesium-silver alloy, aluminum, aluminum-lithium alloy, aluminum-copper
20 alloy, aluminum-copper-silicon alloy.

Further, examples of materials for the luminescence layer 5 may include: in addition to Alq3, BeBq (bis(benzoquinolinolato)beryllium), DTVB2 (4,4'-bis(2,2-di-p-tolylvinyl)biphenyl), Eu(DBM)3(Phen)
25 (tris(1,3-diphenyl-1,3-propanediono)-monophenanthroline)Eu(III)), and further, diphenyl-ethylene derivatives, triphenylamine derivatives,

diaminocarbazole derivatives, bisstyryl derivatives,
benzothiazole derivatives, benzoxazole derivatives,
aromatic diamine derivatives, quinacridone compounds,
perylene compounds, oxadiazole derivatives, coumarin
5 compounds, anthraquinone derivatives, distyrylarylene
derivatives (DPVBi), and oligothiophene derivatives
(BMA-3T).

Further, as mentioned above, a protective
layer can be inserted adjacent to the liquid
10 crystalline organic layer 3. The protective layer may
preferably comprise a material having a large volume
so as to exhibit little diffusivity into liquid
crystalline materials used in the liquid crystalline
organic layer 3. It is further preferred that the
15 protective layer material does not have a liquid
crystal phase of an order equivalent to or lower than
that of a disordered phase at an operation
temperature, and more preferably is a non-liquid
crystal material. Examples thereof may include:

20 α -NPD: bis[N-1-(naphthyl)-N-phenyl]benzidine,
1-TANTA: 4,4',4''-tris(1-naphthylphenylamino)-
triphenylamine,
2-TANTA: 4,4',4''-tris(2-naphthylphenylamino)-
triphenylamine,
25 TCTA: 4,4',4''-tris(N-carbazoyl)triphenylamine,
p-DPA-TDAB: 1,3,5-tris[N-(4-diphenylaminophenyl)-
phenylamino]benzene,

TDAB: 1,3,5-tris(diphenylamino)benzene,

DTATA: 4,4',4"-tris(diphenylamino)triphenylamine,

TDAPB: 1,3,5-tris[(diphenylamino)phenyl]benzene.

[Examples]

5 Hereinbelow, the present invention will be described more specifically based on ~~Examples~~.

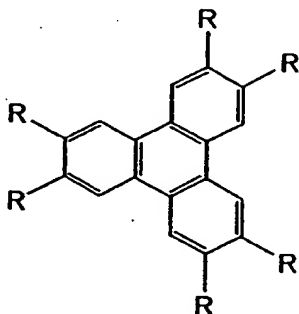
(Example 1)

 An organic EL device having a sectional structure as shown in Figure 2A (which is
10 substantially identical to Figure 1), which is a sectional view taken along a line A-A' in Figure 2B, a corresponding bottom plan view, was prepared in the following manner.

 More specifically, on a glass substrate 11
15 held at 200 °C, a 70 nm-thick ITO film was formed as a hole-injecting anode 12 by sputtering using a target of In 90 wt. % and Sn 10 wt. % while flowing Ar gas at 200 sccm and O₂ gas at 3 sccm. The ITO film showed a work function of ca. 4.35 eV after the sputtering, but
20 was then exposed to ultraviolet rays from a low-pressure mercury lamp ^{in order to achieve} ~~to have~~ an elevated work function of ca. 4.6 eV.

 The above-treated glass substrate 11 having an ITO film 12 was placed in a vacuum chamber held at
25 a pressure below 2.67×10^{-3} Pa (2×10^{-5} torr), and a ca. 35 nm-thick layer of HHOT (hexabis(hexyloxy)-triphenylene) of a formula shown below was formed as a

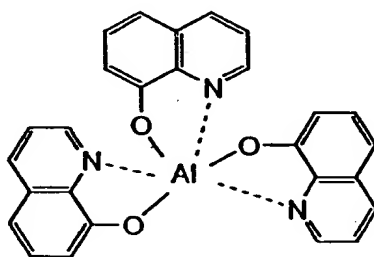
conductive liquid crystal layer 13 on the ITO film 12
by vacuum deposition at a rate of ca. 0.1 nm/sec at a
pressure of 1.33×10^{-3} Pa (1×10^{-5} torr) according to
the resistance heating vacuum deposition method. HHOT
5 exhibited a mobility of 1×10^{-3} cm²/V.sec at ca. 70 °C
or below according to the time-of-flight method.
Incidentally, HHOT is a discotic liquid crystal
causing a transition from crystal to discotic
disordered phase at 65 °C and a transition to
10 isotropic phase at 98 °C.



HHOT

R = C₆H₁₃O

Then, on the HHOT layer 13, a luminescence layer 15 of Alq_3 , represented by a structural formula shown below, was formed in a thickness of 60 nm by vacuum deposition at a rate of ca. 0.1 nm/sec under a pressure of 1.33×10^{-3} Pa (1×10^{-5} torr).



Then, the Alq_3 layer 15 was further coated with a cathode metal 16 comprising a 50 nm-thick layer of Al-Li alloy (Li content = 1.8 wt. %) and a 150 nm-thick Al layer, respectively formed by vacuum deposition to form a device structure roughly as shown in Figure 2A.

In this state, all the organic layers 13 and 15 were in an amorphous (non-aligned) state. In this state, the liquid crystal layer 13 was locally irradiated with $\sqrt{\text{GaAlAs}}$ laser beam (beam diameter = ca. 20 μm , 10 mW) and cooled by standing to ~~be provided~~ produce with locally aligned portions 13b showing a higher conductivity than non-irradiated, non-aligned regions 13a.

As a result, an organic EL device having a sectional structure as shown in Figure 2A was

obtained.

The organic EL device was subjected to voltage application under an electric field of 12 volts/100 nm. As a result, the device exhibited luminescence with different luminescences at laser-irradiated parts 13b and non-irradiated parts 13a as shown in Table 1 below and exhibited a display state as shown in Figure 2B giving a sufficient contrast between the irradiated luminescent parts 17 and non-irradiated non-luminescent parts 18.

Table 1

	Current (mA/cm ²)	Luminance (cd/m ²)
Laser-irradiated aligned parts	3.593	120
Non-irradiated non-aligned parts	0.05	1.5

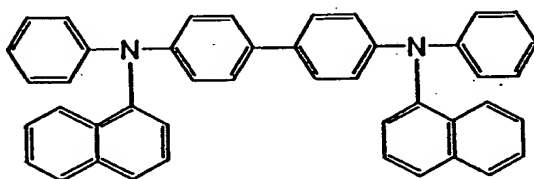
(Example 2)

An organic EL device having a sectional structure as shown in Figure 3 including a pixel structure and a conductive liquid crystal layer 53 having a higher conductivity region 53b corresponding to a selected pixel formed by high voltage application was prepared in the following manner.

A glass substrate 51 coated with a 70 nm-thick ITO layer (anode) 52 and a ca. 35 nm-thick HHOT layer (conductive liquid crystal layer) 53 was prepared in the same manner as in Example 1.

Then, on the HHOT layer 53, a protective layer 54 of α -NPD, represented by a structural formula shown below, was formed in a thickness of 60 nm by vacuum deposition at a rate of ca. 0.1 nm/sec under a pressure of 1.33×10^{-3} Pa.

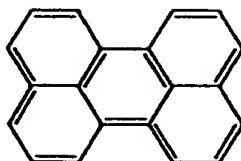
α -NPD



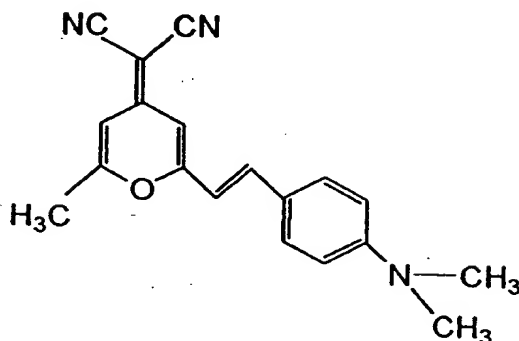
Luminescence organic layer segments 55a - 55c exhibiting different luminescent wavelengths were respectively formed in a thickness of 50 nm on the protective layer 54 by vacuum deposition through a mask ~~under the conditions~~^{with} of a pressure of 1×10^{-5} torr and a deposition rate of ca. 0.1 nm/sec. The organic layers 55a - 55c were respectively formed of Alq3 alone, Alq3 doped with 5 wt. % of perylene for shifting the luminescence wavelength to a shorter wavelength side, and Alq3 doped with 5 wt. % of DCM (a styryl dye) for shifting to a longer wavelength side. The structural formulae for the above-mentioned

perylene and DCM are shown below.

perylene



DCM



The above-prepared organic layers 55a - 55c were respectively coated with cathode metals 56, each comprising a 50 nm-thick layer of Al-Li alloy (Li content = 1.8 wt. %) and a 150 nm-thick Al layer, respectively formed by vacuum deposition, to obtain an organic EL device having a structure as shown in Figure 3.

The above-prepared device was confirmed to exhibit luminescence of respective colors at segments 55a - 55c at an increased luminance at an increased current when maintained at 75 °C.

In this example, only a selected pixel

portion of the organic layers including a luminescence segment (55a in Figure 3) was supplied with a high electric field of 15 volts/100 nm for 3 min[✓] at 30 °C^o, and the other segments (55b and 55c in Figure 3) were not subjected to the high voltage application treatment. Thereafter, all the segments 55a - 55c were supplied with a drive electric field of 5 volts/100 nm at 30 °C. As a result, the segment 55c subjected to the high[✓] voltage application treatment exhibited a selectively high luminance as shown in Table 2 below.

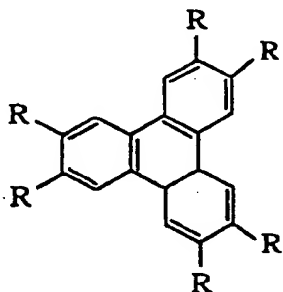
Table 2

15	Current (mA/cm ²)	Luminance (cd/m ²)
	High voltage treatment applied (55a, 53b)	12 300
20	High voltage treatment not applied (55b-55c, 53a)	<0.05 0


(Example 3)

25 An organic EL device having a sectional structure as shown in Figure 3 (before^{the} formation of a different conductivity region 53b) was prepared in the

same manner as in Example 2, except ~~for using~~ HPOT
(hexabis(pentyloxy)triphenylene) of a formula shown
below was used instead of HHOT for providing a
conductive liquid crystal layer 53.



HPOT $R = C_4H_9O$

After the above device preparation, a portion
of the conductive liquid crystal layer 53
(corresponding to a luminescence segment 55a in Figure
3) was irradiated with ^aGaAlAs laser beam (beam
diameter = ca. 20 μm , 10 mW), similarly ~~as~~ ^{to} in Example 1,
to form a different conductivity region (53b shown in
Figure 3).

Thereafter, the device was subjected to ~~the~~
application of an electric field of 12 volts/100 nm,
whereby the irradiated part and non-irradiated parts
exhibited different luminances as shown in Table 3
below.

Table 3

	Current (mA/cm ²)	Luminance (cd/m ²)
5 Laser-irradiated aligned parts (55a, 53b)	11.5	500
Non-irradiated non-aligned parts (55b-55c, 53a)	2.3	90

10

The same device exhibited luminance differences at irradiated parts and non-irradiated parts at an electric field of 10 volts/100 nm as shown in Table 4 below.

15

Table 4

	Current (mA/cm ²)	Luminance (cd/m ²)
20 Laser-irradiated aligned parts (55a, 53b)	3.0	110
Non-irradiated non-aligned parts (55b-55c, 53a)	0.4	18

25

As described above, according to the present invention, it has become possible to provide an

organic EL device having a memory characteristic by including a conductive liquid crystal layer having regions of different conductivities. Compared with a conventional EL device lacking a recordability (memory characteristic) of^a written or display state, the EL device of the present invention can exhibit locally different luminances at an identical drive voltage. This characteristic is available not only in a display device, but also in a memory device.

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→ ABSTRACT OF THE DISCLOSURE ←

A conductive liquid crystal device capable of exhibiting luminescence of different luminances at an identical drive voltage, thus useful as an EL device having a memory characteristic, is provided. The conductive liquid crystal device is formed by a pair of oppositely disposed electrodes and a liquid crystalline organic layer disposed between the electrodes, wherein the liquid crystalline organic layer has plural regions having mutually different electro-conductivities.

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